NASA CR- 144785

NIM AND CAMAC MODULE STUDIES

(NASA-CR-144785) NIM AND CAMAC MODULE STUDIES Final Report, 1 Nov. 1975 - 15 Mar. 1976 (Ortec, Inc., Oak Ridge, Tenn.) 16 p HC $3.50 CSCL 09C

N76-28473

Unclas
G3/33 47057

J. Frank Pierce

ORTEC, Inc.

100 Midland Road

Oak Ridge, Tennessee 37830

March 15, 1976

Final Report for Period November 1, 1975 - March 15, 1976

Prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

GODDARD SPACE FLIGHT CENTER

Greenbelt, Maryland 20771

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No. 1	2. Government Accession No.
3. Recipient's Catalog No.	
4. Title and Subtitle NIM and CAMAC Module Studies	5. Report Date March 15, 1976
	6. Performing Organization Code
7. Author(s) J. Frank Pierce	8. Performing Organization Report No. 1
9. Performing Organization Name and Address ORTEC Inc. Oak Ridge, Tenn. 37830	10. Work Unit No.
	11. Contract or Grant No. NAS 5-22812
	13. Type of Report and Period Covered Final Report Nov. 1, 1975 - March 15, 1976
12. Sponsoring Agency Name and Address Goddard Space Flight Center National Aeronautical and Space Administration Greenbelt, Md. 20771 Technical Monitor - Dr. J. Trainor	14. Sponsoring Agency Code
15. Supplementary Notes	

16. Abstract

Studies were conducted on two NIM and two CAMAC modules to determine the feasibility of adapting these modules for space research. Methods are outlined for reducing the power in each module by approximately fifty percent. Components that could not be replaced from the NASA approved component list are identified. Special problems associated with grounding, vacuum operation, temperature variations, vibration and shock are outlined. Suggested solutions for these problems are discussed.

17. Key Words (Selected by Author(s)) NIM and CAMAC MODULES POWER REDUCTION SPACE INSTRUMENTS	18. Distribution Statement

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*

*For sale by the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

CONTENTS

SECTION 1

INTRODUCTION

1.1 Objectives: Contract NAS 5-22812 was awarded to ORTEC in October, 1975 to investigate the feasibility of adapting two CAMAC and two NIM modules for space studies. The objectives of this study contract were: 1) to estimate the cost of constructing each of the four modules using NASA approved components, fabrication techniques, and component screening and documentation; and 2) to reduce the power consumption as much as possible while maintaining acceptable performance.

The modules specified for study were:

1) CAMAC Model S812, 8x12 Scaler
2) CAMAC Model IR026, Interrupt Register
3) NIM Model 451, Spectroscopy Amplifier
4) NIM Model 455, Timing Single Channel Analyzer

While the major part of this work was devoted to power reduction and component studies, other areas considered were power supply requirements, ground isolation on the printed circuit boards, vacuum operation, temperature ranges, packaging, and vibration and shock problems. In addition, price estimates were made for each module in lots of 10 and 100 units.

1.2 Organization: In Section 2, methods are outlined for reducing the power consumed by approximately 50 percent without seriously affecting the operation of the four module types. The material in Section 3 deals with problems of finding suitable qualified substitutions for the components now used in the four modules. Exceptions are listed so that the trade off in power or performance can be evaluated. Environmental factors are considered in Section 4. Cost estimates are contained in Section 5. The entire study is summarized in Section 6.

SECTION 2

POWER REDUCTION STUDIES

2.1 CAMAC Model S812: The S812 Octal Scaler is an eight-fold 12-binary-bit scaler and is intended for general purpose pulse counting operations at speeds of up to 60 MHz. NIM standard fast logic pulses may be used to drive any of its eight data inputs. The input pulses are counted on an associated 12-binary-bit scaler. In response to the proper CAMAC crate controlled command, this unit will deliver the count of the selected scaler in parallel form into the first 12 CAMAC Dataway R-lines and generate the CAMAC Dataway Q-line response signal.

After a 3-nsec delay, each scaler generates a Busy signal while it is accepting and counting pulses. The Busy signal is fed through a LEMO connector on the front panel and can be used to inhibit other electronic circuits if desired.

The S812 uses only the +6V and -6V power lines. The total power required is approximately 8 Watts.

The input circuits in this module are eight NIM-to-TTL converters. Each converter uses approximately 270 mW or a total of approximately 2.1 Watts for eight converters. The current level used in these circuits is rather high to allow the circuits to respond to 1 ns NIM pulses. The power required could be reduced at least 50 percent if the minimum pulse width could be increased to 8 or 10 ns.

The Busy signal available on the front panel may not be necessary in space work. If this output can be eliminated, approximately 650 mW can be saved in the unit. If a Busy signal is necessary, the power in this circuit can be reduced approximately 350 mW by using low-power Schottky chips to replace the 74107 and the 7400 chips.

Each binary chain consists of one 8291 and two 8293 scalers. The 8291 can be replaced with a 74LS196, thus saving 110 mW/IC. The 8293 is a low power unit that requires less power than the 74LS196. For eight channels, the total power saved would be approximately 880 mW.

In the remainder of the circuit, the following changes can be made. Replace 38 gates with low-power Schottky gates to save approximately 250 mW. Replace twelve 74151 ICs with twelve 54LS151 multiplexers to save approximately 1.1 Watts. If the load on the R-line drivers can be restricted to reasonable levels, a gate from the 5400 series with a fan out of 10 can replace an 8881 gate which has a fan out of 20. This change would save 17 mW/gate or a total reduction of approximately 0.2 W.

Small reductions can be made in other parts of the circuit. However, a reasonable estimate at this time is that the power required by the CAMAC Model S812 can be reduced to 4 W or a reduction of approximately 50 percent. This power reduction is based on the approval of the low-power ICs specified above. By providing +5V from the dc power supply, the power can be reduced by an additional 0.5 W, thus reducing the power required to approximately 3.5 W. Except as noted above, no significant reduction in performance is anticipated. If +5V (or -5V) could be supplied, this unit would not require +6V (or -6V).

2.2 CAMAC Model IR026: The IR026 Interrupt Register is a 12-bit coincidence and latch circuit for storing and recording the occurrence of NIM signals. Inputs are usually roughly shaped detector signals or outputs of high-speed decision networks.

The module uses only the +6V and -6V lines and consumes approximately 3 W of power.

Each of the twelve input circuits uses one emitter follower having a power consumption of 50 mW. By increasing the emitter resistor from 470 ohms to 2 K ohms, the power required by an emitter follower can be reduced to 12 mW with a total reduction in power of approximately 350 mW for the unit.

Twelve chips from the 7400 series (7400, 01, 02, 04, 10, and 20) are used per module. These chips contain a total of 49 gates and use approximately 0.5 W. Replacing some of these chips with comparable low-power Schottky chips will reduce the power required to 0.2 W, thus saving 0.3 W.

The power used by the MECL-to-TTL converters can be reduced approximately 100 mW by increasing the emitter resistors.

Nine type 1010 MECL chips are used in this module. Each chip contains 4 gates with each gate requiring approximately 30 mW of power. These chips could be replaced with MECL 1212 chips which use 16 mW per gate. This substitution would reduce the power from 1035 mW to 575 mW, thus saving 460 mW.

Allowing a 50 mW reduction in the power consumed by the bias resistors, a reasonable estimate for the power reduction in the circuit is 1.26 W at a 5.2 V level. This reduction in power implies a reduction in current of 242 mA. Therefore, the power loss in the series diodes would be reduced from 410 mW to 216 mW for a reduction of 194 mW; most of this reduction occuring in the diode in the -6 V line. Using +5 V instead of +6 V would only save approximately 40 mW in this unit.

Assuming that the required chips can be approved, a power reduction of approximately 50 percent (to 1.5 watts) seems reasonable with existing technology. The presently available CMOS gates appear to

be much too slow for this unit.

In this unit, the ±6V lines would not be necessary if +5 and -5.2V lines could be provided.

2.3 NIM Module 451: The 451 Spectroscopy Amplifier has a versatile combination of switch-selectable pulse shaping and output characteristics. This unit has extremely low noise, a wide gain range and an excellent overload response. Input pulses of either polarity can be shaped and amplified. With a 10 V dynamic range and a minimum shaping time of 0.5 μsec, the unit has a good count-rate stability.

The 451 uses the ±24 and ±12 V power lines and consumes 4.9 Watts of power. A rather large standing current must be maintained in several parts of the circuit in order to produce the high slew rate required by the 10 V dynamic range and 0.5 μsec shaping time. A reduction in power while maintaining this range and minimum shaping time would be very difficult. A 10 percent reduction in power could probably be achieved by using ±6 instead of ±12 V in several places and by increasing bias resistor values in other places.

Other alternatives that are available include a reduction in the dynamic range to 5 V and a reduction in the number of circuit functions. As the unit is now constructed, 4.5 W is supplied by the ± 24 V lines. By reducing the maximum amplitude to 5 V, the 12 V supplies could replace the ±24 V supplies so that the power required would be reduced by approximately 2.3 W. This change would not adversely affect the maximum rate. A further reduction of 10 percent, or 0.36 W, would reduce the power required to 2.34 W.

Very few if any experimental systems use both the unipolar and bipolar output pulses. By using jumpers, one output could be disabled by opening the d.c. power lines to this section, thus reducing the power. With a 10 V dynamic range, the unipolar amplifier and its base-line restorer dissipates 1.3 Watts and the bipolar output amplifier dissipates 1 Watt. At the 5 V dynamic level, the power dissipated would be approximately one half of the above values.

To reduce the standby power in the 451 significantly, the dynamic range should be reduced to 5 V and the layout should allow the option of disabling either of the output circuits. Other changes would not provide much return for the engineering time required. Other than the dynamic range, the performance should not be significantly altered.

2.4 NIM Model 455: The 455 Constant Fraction Timing Single-Channel Analyzer provides both pulse-height and timing analysis for unipolar and bipolar signals. Input signals ranging from 50 mV to 10 V can be analyzed. In addition, five different fractions can be selected for constant fraction timing for either unipolar or bipolar pulses, or zero crossing timing can be selected for bipolar pulses.

The 455 unit uses the ±24 V and ±12 V power supplies and consumes 6.6 Watts of power. This circuit was originally designed to operate with minimum power. Consequently, a reduction in the standby power consumed by 50 percent will require that all unnecessary functions be eliminated and possibly that the maximum pulse magnitude be reduced from 10 V to 5 V.

One apparently unnecessary circuit is the base-line restorer. This circuit uses approximately 0.8 W. The newer constant fraction discriminators do not have base line restorers.

The upper level and the lower level output circuits each use approximately 100 mW of power. Having both outputs may be somewhat redundant in many experiments. Jumpers may be used to disable one or both of these circuits when not needed. The timing TTL output may be treated in the same manner.

In many places ±6 V could be used instead of ±12 V. In addition, bias resistors could be increased to decrease the current. The power reduction problem could be helped considerably by limiting the input signal to a maximum of 5 V. These modifications, which include many circuit changes, could reduce the standby power by 2.2 W. With the above changes and an investment of several weeks of engineering time, the present specifications could probably be satisfied with approximately 50 percent of the present power.

2.5 Summary: While the power required by each of the four modules under study can be reduced by at least 50 percent, a price must be paid in each case. For the CAMAC modules, low power and high speed integrated circuits must be approved. In addition, the minimum width of the input pulse should be increased from 1 nsec to 8 or 10 nsec. For the NIM modules, the dynamic range must be decreased from 10 V to 5 V. In addition, any unused functions should be disabled by removing the power from these circuits. In all cases, the bias circuits should be reviewed with the objective of decreasing the bias currents. Otherwise, the performance should be equal to that of the present modules in each case.

SECTION 3

COMPONENT STUDIES

3.1 Objectives: The objectives of this study were (1) to match the components that are now being used with components that are listed on the NASA Approved Preferred Parts List and (2) to identify critical components that do not have approved replacements but which will have a significant impact on the performance and power reduction areas. These components will require special consideration.

3.2 CAMAC Model S812: All of the components that are necessary to construct the S812 are avialable from the NASA qualified list except the integrated circuits. None of the twelve types of ICs in the present circuit have been qualified and only five qualified substitute types can be located. If the power is to be minimized, only two of the five (the SM5400 and the SM54L00) can be used. The remaining ICs should be selected from the 54LS00 series, none of which are qualified. These data are summarized in Table I.

CMOS technology is not recommended for this unit for two reasons. First, CMOS does not have the speed that is required in the fast part of the circuit (50 MHz). Using CMOS in only part of the circuit results in awkward and power consuming interface circuits. Second, the setup and reset times required by CMOS ICs are at least marginal and probably excessive when operating in the CAMAC time frame.

3.3 CAMAC Model IR026: Qualified substitutions are available for all parts used in the IR026 except the integrated circuits. Of the seven types of ICs used, one can be replaced from the 5400 series and five from the 54L00 series. However, the 54LS00-series must be used if the power is to be minimized. The integrated circuits now used together with possible replacements are shown in Table I.

3.4 NIM Model 451: Except for a delay line and dual bipolar transistors, all of the components necessary to construct the 451 have been qualified. The potting material on the delay line will outgas and should be replaced with a more suitable material.

The dual bipolar transistors used in the 451 are type MD2219A/SD446 (or SGC2539) and are special units made by Motorola. Six dual units are used in each module. These transistors have f_T values of approximately 300 MHz while the closest qualified replacement, the 2N2920, has an f_T of only 30 MHz.

Several qualified transistors are not direct replacements for those now used in the 451. Some engineering time will be required to minimize any ill effect that the small differences might produce.

3.5 NIM Model 455: Three device types are not available from the approved parts list; the dual bipolar discussed in 3.4. a dual N-channel JFET, and a fast comparator. The dual JFET is an ITS3242 in which the offset voltages are closely matched. However, a type FD1735 would be equally good.

A fast comparator with low temperature drift is necessary if good timing stability is to be maintained in the 455. A recommended type is NE529. Unfortunately, none of the fast comparators are low power devices.

3.6 Summary: The major problem that has been identified in the component area is the absence of the following parts on the approved list: (a) a dual bipolar NPN transistor with a high value of f_T, (b) a dual N-channel JFET, (c) a fast comparator, and (d) several low power Shottky gates. Other than these items, qualified parts can probably be substituted for the remaining components.

TABLE 1

UNAPPROVED INTEGRATED CIRCUITS AND THEIR POSSIBLE REPLACEMENTS

Module	IC's Used	Qualified Low-Power Replacement	Nonqualified* Low-Power Replacement
S812	SN7400N	SM54L00	SNC54LS00
	SN7401N	SM54L01	SNC54LS01
	SN7402N	SM54L02	SNC54LS02
	SN7404N		SNC54LS04
	SN74107N		SNC54LS107
	SN74151N		SNC54LS151
	SN74153N		SNC54LS153
	N8250A		SNC54LS138
	N8291		SNC54LS196
	MS8293		SNC54LS196
	N8881A	**SM5400	
	SN15846N	SM54L00	
IR026	SN7400N	SM54L00	SNC54LS00
	SN7401N	SM54L01	SNC54LS01
	SN7402N	SM54L02	SNC54LS02
	SN7404N	SM5404	SNC54LS04
	SN7410N	SM54L10	SNC54LS10
	SN7420N	SM54L20	SNC54LS20
	MC1010P		MC1212
455	MC717	SM54L02	SNC54LS02
	***μA710C		****NE529
	μA739	μA747	

*SNC54LS00 Series to be qualified

**Fan out of 10 while 8881 has fan out of 20

***Fast Comparator

****Not a low power unit

SECTION 4

ENVIRONMENTAL FACTORS

4.1 Objectives: Modules used in space studi[illegible] will be subjected to several environmental stresses. As presently designed NIM and CAMAC modules would not survive these stresses and probably would not operate satisfactorily in space. The objective of this part of the study is to identify adverse environmental problems and suggest changes in the construction of the four modules under study to allow them to withstand the expected stresses.

4.2 Vibration and Shock: The acoustic input near the time of lift-off is substantial. In addition, vibration loads may reach 15 g's for short periods of time. A PC board thickness of 0.062 inch is now used in all four modules. The thickness should be increased to 0.125 inch for the NIM modules.

The PC board should be attached to the outside frame each 2" with screws. In addition, support posts should be located on 2" centers where layout space permits. The components on the S812 are very dense and probably will not permit space for support posts on 2" centers. In this case, fewer support posts can be used if sheets of polyurethane are used to dampen the vibration.

Cover plates should be ribbed or reinforced for rigidity and attached to the frame with screws on a 2" spacing. In addition, the cover plates should be attached to the support posts with screws.

4.3 Vacuum Operation: The NIM and CAMAC units will be operated outside the pressurized compartments in space. This condition could create at least three problems. First, the epoxy or coating used could outgas. Epoxy materials that do not outgas, such as Hysol 1B, should be used.

The second problem is that of cooling the components, especially the transistors and integrated circuits. While the radiation of heat to the surrounding surfaces will provide some cooling, adequate thermal paths to the printed circuit board must be provided for the active devices that must dissipate a significant amount of heat.

The third problem is the possible contamination of transistors and ICs with excess mositure during periods of increasing pressure. To prevent this condition, all active components should be hermetically sealed.

With proper design, none of these three problems are expected to be bothersome.

4.4 Temperature Problems: As presently designed, all four modules will operate satisfactorily over a temperature range of 0° to 50° C. With the addition of special thermal coupling units for some of the hotter devices, no problems are anticipated in the modified units over this temperature range.

4.5 Packaging: New layouts of the printed circuit boards will be necessary to accommodate the changes for space flight use. The design and fabrication techniques outlined in GSFC Specifications S-713-P-SA can be incorporated into the new circuit boards and the subsequent construction work. The density of parts on the S812 is rather high. Some difficulty may be experienced in the new layout of this unit.

4.6 Grounding: In the proposed system, the power supplies will isolate the return side of the primary from the secondary and from the chassis. This condition requires that the printed circuit board ground be isolated from the chassis. This modification should not adversely affect the performance of any of the four modules under study.

4.7 Summary: While the environment in space presents some challenging problems, the four modules treated in this study can be modified to overcome these problems.

SECTION 5

COST STUDIES

5.1 Objective: The objective in this part of the study was to estimate the unit cost of space-adapted modules in lots of 10 and 100. All four module types were considered.

5.2 Component Cost: High reliability, approved components are very expensive when compared with the cost of components used in commercial units. Capacitors were 15 to 20 times more expensive. JANTXV and JANTX transistors and diodes were 30 to 60 times more expensive. Integrated circuits were 30 to 50 times more expensive. Metal film resistors were approximately 10 times more expensive.

Wide variations in some prices were observed from one vendor to another, indicating a lack of stability in the price structure. In addition, many high-reliability devices have long delivery dates.

5.3 Labor: Since each component must be carefully checked and each connection must be carefully hand soldered, the labor cost will be high. In arriving at the estimated cost of labor, the assumption was made that each solder connection would require an average of 1.5 minutes. Inspection and testing will require considerably more time than normally required for commercial units. In addition, the records on components and modules will increase the labor cost.

5.4 Estimated Cost: The following estimates include parts, labor, engineering, layout, and component screening. ORTEC's mark-up is not included in the component screening cost; however, it is included in the other categories.

TABLE 2

ESTIMATED COST PER MODULE IN LOTS OF 10

	IR026	S812	451	454
Labor	$2100	$2800	$2500	$2860
Parts	3100	7670	5200	5240
Engineering	1100	1320	2000	3300
Layout	330	440	1400	440
Screening	1200	1560	1400	1600
Total	$7830	$13790	$11500	$13440

TABLE 3

ESTIMATED COST PER MODULE IN LOTS OF 100

	IR026	S812	451	454
Labor	$2100	$2700	$2300	$2460
Parts	2900	6000	4700	4620
Engineering	110	140	200	330
Layout	30	40	40	50
Screening	700	884	800	740
Total	$5850	$9764	$8000	$8200

While a best effort has been made to arrive at reasonable estimates, the unusual requirements on components, construction and testing may make these estimates somewhat unreliable. If the engineering and layout costs are absorbed in another study, the estimates should be lower.

If only ten units of one module type are to be constructed, the setup and training cost per module would be very large. However, if this front-end cost is prorated over 200 modules, the cost per module would be relatively low.

The relatively large screening cost occurs because Page 09-A of PPL-12 indicates that all JANTX and JANTXV transistors must be rescreened. If improvements have been made by the vendors so that rescreening is unnecessary, then the screening cost may be reduced to a relatively small value. The screening cost figures listed cover the screening of all diodes, transistors, and microcircuits. In addition, the cost for parts includes the 30% expected mortality rate in the screening of semiconductor devices.

If the engineering and layout cost are covered by an extension of the present contract, these should be deleted from Tables 2 and 3. The final cost figures may be much less than indicated by the totals in Tables 2 and 3.

5.5 Summary. Unit cost estimates are provided for the module types in lots of 10 and 100. Compared with the cost of commercial units, these figures are rather high. Better estimates can be submitted after some experience in constructing and testing space adapted instruments is obtained.

SECTION 6

RECOMMENDATIONS

This study indicates that the power used by the four module types specified can be reduced significantly, probably as much as fifty percent or more. All four instruments can be adapted for space work. However, the high-reliability parts and the large amount of hand labor that must be used will cause the cost per module to be many times that of the commercial equivalent. At this point in the study, the cost estimates may not be very reliable.

To provide more reliable data, the major recommendation is that this study be extended to the construction of prototype units.